

## ECONOMIC SYNERGETICS AS A SCIENTIFIC THEORY OF COMPLEX SYSTEMS DEVELOPMENT

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**Abstract.** The given article is devoted to overcoming crisis phenomena in the economic life of Russia in the first quarter of the 21st century, based on mastering the principles of economic synergetics. The applicability of the modern economic paradigm to Russian conditions is being questioned. The methodological bases of the given article are the cognitive principles of the study of economic processes, taking into account openness, nonlinearity, irreversibility, complexity and other characteristics not previously considered in the analysis of economic systems. As a result of the study, the applicability of the principles of synergetics to the processes of development of economic systems was established. We should also take into account some new factors (nonequilibrium, irreversibility, nonlinearity, etc.).

**Keywords:** economic development, synergetic factors of development, complexity, economic synergetics, self-organization in economic systems, phase and structural transitions, a bifurcation model.

### 1 Introduction

Despite the efforts, made by the government of the Russian Federation, regions and municipalities, the decline in living standards has been going on for five years. The technological gap of Russia is growing not only with the advanced countries of Western Europe, the United States but also with the countries of Southeast Asia (in terms of GDP, Russia is more than 5 times behind China).

Experts explain the unsatisfactory economic development of Russia by the inability of the applied economic mechanism, including the theoretical basis of economic strategies. It can't also cope with the complexity of transition processes at the global and national levels.

The role of synergetic factors of economic development has recently increased, including: nonequilibrium, irreversibility, nonlinearity, non-integrability, etc. Such factors as self-oscillations, autocatalysis, fluctuation turbulence and kinetic mobility intensified during transitional periods of development and entropy instability, creating self-organization processes which are incomprehensible for a modern economic science.

In 1992 Kuznetsov B.L., the professor of Kama Polytechnic Institute (now the Naberezhnye Chelny Institute of Kazan Federal University), introduced a special section which he called "economic synergetics" during his lectures of the general theory of systems. Thus, in his class an attempt was made to explain the effect of new factors of development from the standpoint of the theory of self-organization in complex systems, based on the works of A.A. Bogdanov (Bogdanov, 1989), a Nobel laureate I.R. Prigozhin (Prigogine & Stengers, 1984) and the theory of synergetics by G. Haken – the professor of Stuttgart University (FRG), who published the book "Synergetics" (Haken, 1983) in Springer in 1975. The book was met with attention in a number of scientific centers in Russia (Moscow State University, IPM named after M.V. Keldysh, Moscow Engineering Physics Institute, etc.). The main ideas of synergetics were supported by such academics and professors as: Samarsky A.A., Krasovskiy A.A., Kurdyumov S.P., Moiseev N.N., Legasov V.A., Kapitsa S.P., Malinetskiy G.G. and other famous scientists of the Russian Federation (Knyazeva & Kurdyumov, 1994; Malinetskiy, 2006). The seminars on synergetics at Moscow State University were led by V.A. Sadovnichy – the rector of the academician.

The journal "economic synergetics" has been published in Kama Polytechnic Institute since 1995 (since 2012 it's an electronic resource). Thanks to the journal several disciplines, based on the principles of self-organization and synergetics, were introduced.

At the same time, a book "Synergetic economy" by Chinese professor V.B. Zang began to be published abroad in the publishing house "Springer". "Synergetic economy" (Wei-Ben, 1999) was translated into the Russian language in 2000. Translators did not see any difference between the meaning of the concepts "Economic Synergetics" and "Synergetic Economy". Conceptually, the economic synergetics, developed in Kama Polytechnic Institute and the synergetic economy of V.B. Zang have no fundamental differences, but they differ in format and the way of presentation.

Therefore, in Russia, the "economic synergetics" option has received the highest priority in scientific circulation.

In 2004, at the First International Scientific and Practical Conference "The strategies for Dynamic Development of Russia: Unity of Self-Organization and Governance" in the walls of the Russian Academy of Public Service under the President of the Russian Federation, the report: "Energy-technological approach to the formation of synergetics in systems" was made by the Department of Economics, Organization and Production Management (EUP) of Kama Polytechnic Institute.

In 2006, the Center for Dynamic Development Strategy by S.P. Kurdyumov published a report of the Department of EUP of Kama Polytechnic Institute "Synergetic Management - Breakthrough Management Technology" in "The Future of Russia in the Mirror of Synergetics" journal, edited by G.G. Malinetskiy. Thus, the concept of Russia's technological and socio-economic breakthrough in development has a condition of common goals and objectives.

### 2 Methods

Synergetics as a methodology began to develop in ancient times. The term "Synergetics" is found in the famous work of ancient Greek philosopher Aristotle's "politics" is a meaningful collective action of different nature forces, coordinated in space and time.

The issues of self-organization in systems attracted attention of scientists of the middle Ages and the Late Times.

It is necessary to distinguish the contribution of A.A. Bogdanov, who in his work: "Tectology - Universal Organizational Science", which was published in St. Petersburg from 1913 to 1926, singled out self-organization as the most important form of system development. He drew attention to positive feedback as an important element of self-organization.

Some prominent scientist of the 20th century, Nobel laureate Ilya Romanovich Prigozhin (1915-2003), who is considered one of the fathers of synergetics science, used an entropy approach to explaining the processes of self-organization in systems. Formation of ordered structures he tied with export/import of entropy. As one of the fathers of the theory of unbalanced thermodynamics in thermal structures, he gave a methodological basis for formulating the principles of economic synergetics in the most complete form. An important contribution of I.R. Prigozhin was the development of the theory of bifurcation (branches), which established the equality of determination and randomness in the dynamics of complex systems. It opened the possibility, not of singularity, but the plurality of "correct decisions", depending on the ratio channels of positive and negative feedback.

His contemporary N. Winer, who was recognized as the founder of cybernetics, did not deny the possibility of systems in which there may be superior positive feedback over negative feedback, but he considered it as an exception from rules, leading to the destructive behavior of the system. The great mathematician was wrong. This property has all complex systems, and thanks to this development it is carried out.

Until 1975, when G. Haken's book "Synergetics" was published in «Springer» (Germany) and attracted widespread attention to this science, the term "synergetics" was used in the works of American economists: P. Drucker, I. Ansoff and a sociologist A. Maslow, mathematicians: S. Ulam, N.N. Moiseev, a physiologist: D. Sherrington and other researchers.

Synergetics by G. Haken was a major event in the world of scientific theories, related to the magnitude, complexity, nonequilibrium, nonlinearity, uncertainty, the co-evolution.

Synergetics by H. Haken includes the formalization in the form of equations, borrowed from the great physicists.

1. The Langevin-type equation for a set of variables:

$$\dot{q} = N(q) + F(t),$$

Where  $N(q)$  – is a non-linear function that reflects deterministic factors;

$F(t)$  – describes the action of random forces in system development processes.

2. If the  $F$  function itself depends on the variables, the Ito-Stratonovich equation can be applied:

$$dq = N(q)dt + dF(t, q),$$

Where  $q$  is the order parameter (the dominant development factor).

1. The possible approach uses the Fokker-Planck equation:

$$f\dot{q} = L(q, T),$$

where  $L$  is a line operator operating on the  $f$  function.

1. Non-linearity can be described using path integral intervals (attractoram), which is produced in the process of solving equations 3.

2. When learning Markov processes, you can use the Chapman-Kolmogorov equation:

$$P(m) = \sum_n m_1 n * P_{(n)} - P_m \sum_n w_{n_1} m$$

Where  $R$  is a distribution function.

1. The Schroedinger's evolution equation is the final condition of self-organization:

$$x_{n+1} = ax_n(1 - x_n)$$

The synergetic of G. Hakena has no original equations, but there are several new principles, for the first time they contained:

- the principle of captivity, which states that all variables can be explicitly and unequivocally expressed through a set of parameters,  $\xi$ ,  $\varphi_n$ , etc.
- synergetics sees self-organization as the first phase of the transition from chaos to order.
- to describe the situation near the phase transition point of the Ginzburg-Landau equation is used, which received the status of a universal principle;
- In unbalanced phase transitions, there are phenomena called "limit cycles" that allow you to describe the most likely outcomes;
- classes of universality do not depend on the microscopic mechanisms but depend on nonequilibrium phase transitions.

Thus, through the set of these principles, the following statement is substantiated: synergetics is the intersection of non-linearity and stochasticity.

### 3 Results And Discussion

In the early 1990s, «Springer» published a book «Synergetic Economics» by Severerg. In this regard, some researchers are trying to oppose the Zang's synergetic economy and the synergetic economy by Economic Department of Kama Polytechnic Institute. There are no particular contradictions in the statement, but the version of Zang is more formalized. The version of Kama Polytechnic Institute is "softer" and has deeper epistemological and cognitive roots in history, philosophy and economic theory in the Russian statement.

The arguments in favor of the version of Kama Polytechnic Institute:

1. In Russia and in many other countries of the world, the interpretation of "economic synergetics" has been established and is widely accepted.
2. Synergetics has expanded the potential of system theory: it has removed some limitations in the form of laws of physics, chemistry, biology, etc. Using the entropy approach by I.R. Prigozhin, synergetics can explain the processes of "internal self-organization" and a wide range of modes of their implementation, depending on the conditions of the external environment.

Economic version of synergetics by Kama Polytechnic Institute has already projected a number of processes in the business and talks about the viability of it in practice (folk enterprises, synergetic trajectory of development in the form of regimes with peaking, interoperability on the verticals and horizontals, creating studies development structures from fluctuations, bifurcations through cascades of phase transitions to sustainable clusters). New management principles are laid open, having systems and management tools. The principles of economic synergetics are universal and take into account the large-scale factor, longevity, historical genesis in the development of the neural network, "hybrid", "blurred", unstructured, and etc. systems. The arguments give us hope for the success of economic synergetics to form a new synergistic way of thinking.

For example, the model of demographic development of the S.P. Kapitsa, built on the synergistic views, warns against logistics growth limit mankind in the twenty-first century (Kapitsa, 2006). There is no currently single version able to somehow describe the behavior of complex and more complex systems except synergetics in the world.

The higher the methodological potential of economic synergetics is, the more flexible it will be. The multiplicity of attractors at the points of bifurcation is a complex process to which science does not know how to approach, but there has already been some progress in the ability to describe the conditions of the task. The Ideas of E.N. Knyazeva and S.P. Kurdyumov deserve interest. They designate the attractors like structures in nonlinear systems, where various processes of evolution in different natures as a result of attenuation in transitional processes are kept. The core of an effective economic synergetics methodology is the most general concepts and approaches based on them, which will be developed as a tool for solving specific problems. And here the economic synergetics has a great potential. Most of the problems solved in practice are related to "blurred" problems. Economic synergetics allows the use of heuristic principles with the deductive approach, the most successful in addressing the "blurry" problems. Synergetics is open to methodology "analogies". Synergetics is compatible with "abstraction" and intuition approaches. The network programming is very promising in future.

Economic synergetics can be used for the formation of boundary conditions. Other approaches compatible with the principles of

economic synergetics can be used: plektis - the interweaving of simple and complex, fractal likeness and others.

All this allows realizing both "soft" and "hard" economic benefits of synergetics methodology. In Russia works effectively scientific school, developing synergic presentation led by G.G. Malinetsky. In the United States, a synergistic approach to capital markets has been successfully developed. Complex and more sophisticated systems can not be managed by conventional techniques and seem unmanageable. If it is the easiest way to manage a system dominated by vertical connections, then complex and ultra-complex systems with horizontal connections require special techniques without guarantees of success.

There are recommendations for the management of complex systems based on deterministic chaos: using trigger points (the most sensitive to changes in the system) and the "other" in which you can manage complex systems, for example, crowds of people, rose at the social resistance to the current regime. Using a deductive approach, decomposing complex into simpler components, dividing large-scale systems into shorter-lived (or, conversely, long-lived) parts, the use of plektis (weaving complex with simple), hybridization, etc.

Self-organization and management are not compatible with semantic content. And in this is the greatest difficulty of synergetic management in complex systems.

Economic synergetics as a scientific direction requires the deployment of cognitive, gnoseological and semantic levels. Its purpose is of high importance and the price of failure is great. The matter is that, self-organization and administration serve as antagonism meets on this level the approval of D. Bruno: "If you can't bring the subject to his antagonism, you do not know this subject". Like the "order of chaos", paradox, the intransigence of self-organization and governance opens the way to the truth.

The challenge is to move from deterministic thinking to the more complex – synergistic one. The technological revolutions of the 21st century lead not only to good things but also to the new challenges. New robotic technology can play a role of Frankenstein and not only locally but also at a global level. To prevent this from happening it is necessary to proceed from the call to the humanity of the member-correspondent of the RAS, the former director of the IPM. M. V. Keldysh Sergey Kurdyumov: "Humanity does not have time to grope the organization of the world through trial and error...; we must calculate and design the future, based on science, on the laws of organization and self-organization. Synergetics is an optimistic attempt to master a non-linear situation and overcome confusion in the face of the discovering complexity of our world." (Kuznetsov, 1999).

The same opinions were outstanding scientists in Russia: N.N. Moiseev, A.A. Krasovsky, S.P. Kapitsa, A.A. Samara, V.A. Legasov, etc.

Therefore, economic synergetics is at the start of the journey. The complexity of the tasks facing the country and their urgency requires great creative development. Synergetic countries competing with Russia have high hopes. In Santa Fe (USA) and San Francisco (USA) powerful centers have been created to develop the synergistic potential for action on a global scale.

The figure provides a diagram of the formation of strategies for solving problems based on economic synergetics.

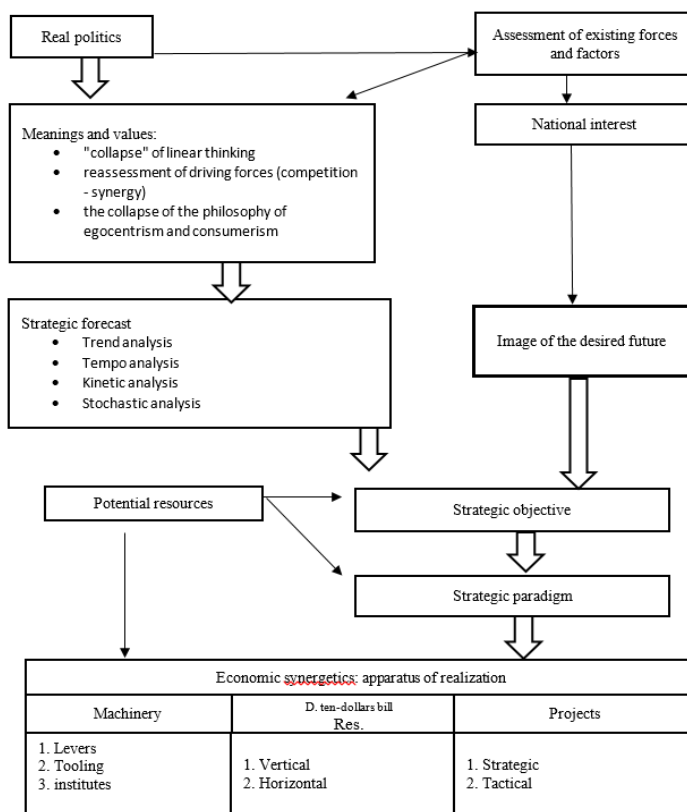


Figure 1. Algorithm for the formation of the economic policy of the state, ensuring economic security and effective socio-economic development based on economic synergetics.

#### 4 Summary

Based on the analysis of the dynamics of complex systems, the following conclusions can be drawn:

- An insignificant part of the world around us is accessible to science, and this is the main reason why “final” conclusions are impossible;
- synergetics and economic synergetics at this stage of studying the development of complex systems can be considered as a promising direction in mastering the mechanisms and tools for influencing the development of complex systems in the desired direction;
- The main advantage of economic synergetics is the deepening of unifying impulses, and not the forces that contribute to the struggle of all against all.

#### 5 Conclusions

Wise words were expressed by Carl Sagan, a popular American scientist: “We live almost without understanding anything in the structure of the world. We don’t think about what kind of mechanism gives rise to sunlight, which ensures our existence, we don’t think about the gravity that holds us on Earth, preventing it from dumping us into space...

... Few people puzzle over why nature is such, what it is where Cosmos came from and whether it always existed?

... The development of science moved forward mainly due to similar issues.” (Hawking, 2004).

So economic synergetics will probably come to the aid of humanity to help get out of the crisis, which threatens to split this world.

The authors of this article believe in a happy synergistic outcome.

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